Minnesota broadband development policy: An analysis of fixed-cost and direct usage subsidies

A Plan B Paper

In Partial Fulfillment of the
Master of Science in Science, Technology and Environmental Policy
Degree Requirements
The Hubert H. Humphrey School of Public Affairs
The University of Minnesota

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May 19, 2015

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Abstract

Broadband has become increasingly important in our daily lives. It creates a high-speed information highway that delivers services in a digital form, making them easier and cheaper to access from a distance. Minnesota legislature recognizes the importance of broadband technology and has taken many steps to make it available to every Minnesota resident. There are currently some areas that do not have access to broadband Internet at the statutory speed as well as residents who do not subscribe to the service. The lack of service and low adoption rate ask for the state to take some actions due to hundreds of millions of dollars in benefits that can be earned as broadband adoption rates increase. This study investigated three subsidy models, a fixed-cost subsidy model and two usage models, on how each one would address the aforementioned problems. The study referred to the number of locations passed and the number of added subscribers as the criteria to measure the effectiveness of each model. The results showed that each subsidy model would be effective at addressing different problems: the fixed-cost subsidy for the lack of broadband service in unserved areas, and two usage subsidy models for low adoption rate problems. The state may need to revisit its broadband goals, especially on broadband adoption, to determine what aspect of the broadband problem that Minnesota policymakers want to address, because these subsidy policies would require different amounts of funding and they focus on different problems and audiences.

1. Introduction

Broadband Internet contributes greatly to our current activities and interactions by allowing digital information to travel at much higher speeds than previous technologies. Broadband enables a richer, more immersive Internet experience with more diverse applications from entertainment to business meeting and remote patient diagnosis. Minnesota legislature recognizes the impact of broadband on its economic development and has taken steps to ensure that it has one of the best broadband networks in the United States. Minnesota has come a long way in increasing broadband penetration. About 78 percent of Minnesota households have access to broadband that meet the minimum statutory speeds of 10 Megabits per second (Mbps) download and 5 Mbps upload that the legislature recommends for basic Internet applications (e.g. government services, interactive video, distance education, etc.) (Governor's Task Force on Broadband, 2014b). Still, about 22 percent of Minnesota households have no access to any broadband service, most of which are in

rural areas (see Figure 1). Many policies introduced recently are trying to solve this problem. One of these is to incentivize Internet service providers to expand their infrastructures to the areas where service is unavailable without a subsidy. The Office of Broadband Development recently awarded grants under the Border-to-Border Broadband Development Program, which provides a subsidy for the construction of broadband infrastructures. The legislature is considering appropriating more funding into this program (Gazelka & Saxhaug, 2015; Kresha et al., 2015). However, funding broadband infrastructure might not translate into higher broadband adoption. Recent survey studies show that the high monthly broadband fee is the most cited reason for not subscribing to the service. A direct subsidy on broadband fees might provide a simple fix in response to the survey result. This study analyzes both types of subsidy, a fixed-cost subsidy on infrastructure construction and a usage subsidy on broadband fees; what are the differences between them and how would each type of subsidy affect broadband development in Minnesota?

2. Literature review

2.1 Definition of broadband

The broadband definition varies on different criteria such as capacity or functional characteristics. In general, broadband refers to a high-speed, always-on connection that supports multiple devices simultaneously. Telecommunication organizations started to use the rate of data transfer or connection speed to define what broadband is. The Federal Communications Commission first defined broadband in 2000 as "*any service with a download speed of 200 kilobits per second or faster*" (The Executive Office of the President, 2015). The definition was changed to 4 Megabits per second (Mbps) for downloads and 1 Mbps for uploads in 2010 before the latest update in 2015 in which the FCC defined broadband as a capacity of at least 25 Megabits per second (Mbps) for downloads and at least 3 Mbps for uploads (The Executive Office of the President, 2015). For Minnesota, the legislature set minimum statutory broadband speed of 10 to 20 Mbps for downloads and 5 to 10 Mbps for uploads (Minnesota Statue 2014, §237.012). These speeds are set to ensure that broadband subscribers can utilize the network for their data-intensive applications. The Broadband Task Force envisioned Minnesotans would use this high-speed connection for applications like government services, security, distance education, business and telemedicine (Ultra High-Speed Broadband Task Force, 2008).

2.2 Benefit of broadband

Broadband technology allows digital information to transfer at high speed, enabling more Internet applications as the speed increases (see Table 4). Consumers use the Internet to buy goods, pay bills, and communicate with each other. Farmers can buy seed and fertilizer online, check market prices, and sell their products. Patients in rural areas can receive faster, higher quality of health care with electronic medical records and remote diagnoses from specialists (Whitacre, 2011). Broadband also creates new types of jobs in the served areas, especially in the information technology (IT) industry. For example, companies are outsourcing some of their operations to rural American cities to take advantage of lower wage labor with the help of high-speed connections (Alsever, 2010; Dugan, 2014). For governments, broadband provides a channel to inform and serve the people with governmental services, such as ordering a fishing license from the Department of Natural Resources' website (Ultra High-Speed Broadband Task Force, 2008).

Broadband increases productivity and improves standards of living by making many services easier to access. Many broadband studies therefore link broadband to economic development. A study by Gillett et al. shows that broadband has positive impacts on various economic indicators (Gillett, Lehr, & Sirbu, 2006). They collected data from the FCC on broadband[1] deployment and Census data on economic activity in businesses and households across the United States. Using econometric regression analysis by state as well as by zip code, they found that during the period from 1998 to 2002, broadband added about 1-1.4% to the employment growth rate, 0.5-1.2% to the number of business establishments, and 0.3-0.6% to share of establishments in IT-intensive sectors. They observed a reduction in the share of small establishments by about 1.3-1.6%, but, due to data limitations, they could not draw a conclusion that broadband had an impact on firm organization. They also found that housing rents, a proxy for property values, were more than 6% higher in 2,000 in zip codes where broadband was available by 1999.

Czernich et al. analyzed the effect of broadband infrastructure on economic growth using panel data from 25 countries in the Organization for Economic Co-operation and Development (OECD) in 1996-2007. The study used the number of broadband subscribers per 100 inhabitants

[1] Gillett et al. used the FCC's definition of broadband of any line with 200 kilobit per second (Kbps) or higher in at least one direction.

from the OECD *Broadband Portal* as the metric of broadband penetration and obtained economic performance data from the OECD *Economic Outlook*. The study defined broadband as a line with download speeds of 256 Kbps or higher. The starting date of 1996 was chosen to provide a clear look at economic performance data from OECD countries prior to the introduction of broadband in 1997. Based on a difference-in-difference regression model and an instrumental variable model, they were able to isolate the causal effect of broadband infrastructure on economic growth. They found that GDP per capita increased by 2.7-3.9% after a country had introduced broadband and annual growth in GDP per capita increased by 0.9-1.5% as the broadband penetration rate increased by 10 percentage points (Czernich, Falck, Kretschmer, & Woessmann, 2011).

Connected Nation, a national non-profit organization working to expand broadband access and adoption, used broadband subscriber growth in Kentucky from 2005 and 2007 and impact factors (such as broadband impact on employment) from literature and surveys as a model. It projected impacts on the national economy assuming the United States had deployed nation-wide broadband (like Kentucky did) with at least 256 Kbps in one direction. The study was used by Connect Minnesota, an affiliation of Connected Nation, to estimate that the Minnesota economy would grow by $517 million for a percentage increase in broadband adoption (Governor's Task Force on Broadband, 2014a). The study projects over $300 million in direct annual income growth, over $100 million in annual value of hours saved from doing transactions online, $20 million in average annual mileage costs saved, $1.7 million in average annual health care costs saved and other benefits if Minnesota had statewide broadband expansion program like Kentucky (Governor's Task Force on Broadband, 2014a).

Other studies looked into broadband's impact on rural areas as more activities are being digitized. Broadband can provide access to activities that would otherwise be expensive and scarce in non-metro areas. Stenberg et al. state that broadband availability has a direct impact on the well-being of communities. Their research discussed many uses of broadband for rural communities such as telemedicine, distance education, and telework. Broadband connections allow rural citizens to benefit from these applications in their homes or local institutions at reduced cost (Stenberg et al., 2009). In telemedicine, for example, they cited Whitacre's study of rural communities in Arkansas, Oklahoma, and Texas. Whitacre collected data such as hospital characteristics and telemedicine uses from 24 rural hospitals and estimated the economic impacts

on rural communities in his study. He found that telemedicine helped each rural community create at least $20,000 per year from saving or economic opportunities, where the average economic impact from broadband in his sampled communities was around $522,000 per year (Whitacre, 2011). Kandilov et al. demonstrate the benefit of broadband infrastructure on the agricultural sector. They collected data from the 1997, 2002, and 2007 Censuses of agriculture and broadband loan information from the US Department of Agriculture. They posit that broadband technology[2] grants farmers access to new technology, management practices, and relevant information such as real-time weather conditions which improves productivity. Using a difference-in-difference model, they found that farms in counties that received broadband loans had about a 3 percent increase in profit (Kandilov, Kandilov, Liu, & Renkow, 2011). Larose et al. studied the impact of rural broadband grants by the Rural Utilities Service from 2005 to 2008. They found that broadband, with download speeds of at least 768 kbps, can improve rural healthcare, education, library resources, employment opportunities, social interactions, and government services (LaRose, Strover, Gregg, & Straubhaar, 2011). These studies and examples show that broadband is a very useful and important technology for economic and social development.

2.3 Broadband externalities and market failure

Broadband can provide benefits and useful applications that even accrue to non-broadband subscribers. These benefits are called externalities, which occur when a market participant's action affects others without being compensated or penalized. Broadband positive externalities create non-excludable social benefits to everybody in the served community. In other words, a community can benefit from broadband even if only some of its citizens pay for the service.

Robert Atkinson, the President of the Information Technology and Innovation Foundation (ITIF), a Washington D.C.-based Think Tank, posits that broadband generates four types of externalities: 1) network externalities, 2) "prosumer" externalities, 3) competitive externalities, and 4) regional externalities (Atkinson, 2007). Network externalities refer to the increased value as more users participate in the network, for example, you can communicate with more people if they are also on the network (Mayo & Wallsten, 2011; Peha, 2007). Prosumer externalities refer

[2] According to the USDA's Rural Utilities Service, the broadband loans had the requirement for broadband speeds of at least 200 kbps in both directions beginning in the pilot program in FY2001. The restriction was removed in FY2013 (Kruger, 2013). The new speed requirement is 5 Mbps download and upload combined (Connected Nation, 2014).

to the idea that broadband might make consumers more efficient and increases productivity and growth. Examples from Whitacre's study would fall in this category as the deployment of broadband allows rural hospitals to operate more productively through telemedicine. Competitive externalities give the served community a competitive advantage in other industries, especially IT. One example is the trend in "onshoring" or rural sourcing, a practice where IT-related jobs such as technical supports or software development are outsourced to domestic communities. Broadband technology increases rural communities' competitive advantage over other offshoring destinations like India or the Philippines. Current examples of rural sourcing locations in the U.S. are Jonesboro, Arkansas and Nebraska's Loup City (Alsever, 2010; Dugan, 2014; Soderlin, 2013). Regional externalities provide served locations the advantage to the presence of broadband in that area. For example, areas without broadband may see properties lose as much as 20 percent of their value (Perry, 2014).

With a long list of both individual and social benefits, broadband may be considered as a very important infrastructure for both economic and social development and it should be available to everyone everywhere. However, broadband is not yet ubiquitously available; 22 percent of Minnesota households do not have access to 10/5 Mbps broadband, meaning that these households do not have infrastructure that connect them to the backbone service. Moreover, only 38 percent of Minnesota households subscribe to 10 Mbps broadband or faster[3], which means most subscribers are on slower connections. The lack of broadband demand and supply can be considered a market failure as there are vast benefits of using broadband and from the externalities. The problem stems in part from the fact that deploying broadband infrastructure can be extremely costly, depending on the distance and broadband technology. Table 1 below shows that in general, costs to connect or "pass" a household or a business to broadband are higher in rural areas. These costs can be a barrier for service providers to further expand their services.

[3] Based on Akamai Research http://www.akamai.com/stateoftheinternet/soti-visualizations.html#stoi-graph

Table 1 Cost per household or business passed

	FTTP/FTTH	Hybrid Fiber Coaxial (DOCSIS 3)	ADSL2+	Wi-Fi/Fixed Wireless	Cellular Wireless (LTE)
Urban	$2,500	$500	$320	$250	$500
Suburban	$2,500	$1,000	$520	$600	$600
Rural	$6,000	$2,500	$1,700	$1,000	$775+

(Governor's Task Force on Broadband, 2012)

The problem intensifies for rural markets. Deploying broadband in rural areas is already more expensive compared to urban areas due to greater distances and the low density of population. It is costly to provide the last mile connection, the final stage of connection that reaches customers, to distant households. Broadband providers may expect even less gain as there are fewer potential customers with a sparser population. Internet service providers therefore put development priority on a more compact, densely populated areas like urban areas because the deployment costs can be shared with more people, which makes it cheaper to provide services on a per household basis.

Gómez-Barroso and Pérez-Martínez assessed the economic reasons for the public intervention in telecommunication based on Joseph Stiglitz's theory on market failures. Their study investigated the possible market failures in four main arguments:

- The characteristics of the good (public goods, merit goods, and externalities.
- The market situation (imperfect competition and incomplete markets).
- Macroeconomic arguments (development, employment).
- Equity

They posit that telecommunication services like telephone or broadband have sufficient reasons to fit in some of the four categories of market failures (Gómez-Barroso & Pérez-Martínez, 2005). They definitely provide positive externalities, as well as they are certainly a main factor in economic development. They also state that, due to the importance and the benefits, telecommunication services should be provided to everyone (Gómez-Barroso & Pérez-Martínez, 2005). While their study do not say, based on economic theory, that public intervention is required, increased broadband deployment and adoption would generate public benefits, as already

mentioned. The government should therefore intervene to increase broadband accessibility and adoption rates.

2.4 Fixed-cost subsidy

The fixed costs are costs that do not increase with the number of subscribers. In the case of broadband development, the costs of infrastructures are fixed at the beginning of the project and do not change after the construction is complete. A fixed-cost subsidy would help service providers to enter the market by lowering the net cost of entry, which would lead to more service provision. A Fixed-cost subsidy is the main approach in broadband development in the past decade as governments around the world realize the technology's effects on the economy and its positive externalities. For example, Canada's 2009 budget aimed to subsidize the private sector to deploy broadband in unserved communities with approximately $181 million (Qiang, 2010). The US also appropriated $7.2 billion as part of the American Recovery and Reinvestment Act of 2009 to Rural Utilities Service and Broadband Technology Opportunities Program to provide more broadband access to consumers in unserved and underserved areas (Qiang, 2010).

At the state level, Minnesota is providing a subsidy for infrastructure construction via its Border-to-Border Broadband Development Program. The project received $19.4 million of total appropriation to help fund 17 broadband projects across the state, covering over 6,100 unserved and underserved premises (Governor's Task Force on Broadband, 2014b). Through the expansion of broadband infrastructure, customers will have options to subscribe to broadband service, which will increase broadband adoption.

2.5 Usage subsidy

Connect Minnesota conducted research surveys on how Minnesota residents and businesses adopt and use broadband (4/1 Mbps) in 2014. The data show broadband adoption gaps among demographic groups and geographic locations. There is an almost 30 percent gap in broadband adoption rates between the Minnesota average (77 percent adoption) and low-income households (48 percent adoption) and an almost10 percent gap between the Minnesota average and rural households (68 percent). The survey captures the major reasons for not having broadband: 19% of residents said the monthly cost is too high, 13% do not need access at home, 8% think they will not use the Internet enough to make it worth the cost, and only 7% of the respondents say broadband is not available in their areas (Governor's Task Force on Broadband,

2014b). This shows that the lack of broadband infrastructure is not the biggest reason for non-adopters, the price is.

A natural approach to increase broadband adoption in this case is to subsidize each user to subscribe to broadband. Lowering the price users have to pay to get service should naturally increase the consumption, especially for those who cannot afford the service otherwise. The Minnesota Broadband Task Force suggested that Minnesota should have "a strategy aimed towards people who, for financial or other socioeconomic reasons, are not currently connected to the Internet." One of the Task Force's recommendations was establishing a low-income eligible threshold to obtain reduced cost of basic Internet service. The Task Force proposed using similar standards that already used in Minnesota such as total household income that does not exceed 135% of the federal poverty guidelines (Ultra High-Speed Broadband Task Force, 2008).

Rosston et al. conducted an Internet survey of 6,271 respondents from all 50 states and used the information to estimate marginal utility and willingness to pay for using a regression model. They observed increased valuation of broadband (i.e. higher willingness to pay) after experience with it and suggest that providing support for initial broadband adoption such as discounted service can potentially increase overall broadband penetration in the U.S. (Rosston, Savage, & Waldman, 2010). The magnitude of change in broadband demand due to its price is explained by its price elasticity. Many studies on price elasticity of broadband demand used survey results based on an individual's willingness to pay for Internet service. Goolsbee used the 1999 survey result from a market research company, Forrester, and estimated the price elasticity for broadband at $40 of -2.75 on average, range from -2.15 to -3.76, depending on the market (Goolsbee, 2006). Dutz et al. also used survey results from Forrester and estimated price elasticity of broadband demand. They studied the price paid for broadband services based on a survey of 30,000 heads of households from the top 100 metropolitan statistical areas of the U.S. from 2005 to 2008. Using a regression model, Dutz et al. observed that price elasticity declined from -1.53 in 2005 to -0.69 in 2008. They concluded people were decreasingly willing to change their broadband consumption in response to a change in price as they perceived it as a household necessity (Dutz et al., 2012). Carare et al. used the 2011 survey data from Connected Nation on non-adopters' willingness to pay for broadband from the heads of 15,082 households in seven states: Alaska, Iowa, Michigan, Minnesota, Nevada, South Carolina, and Texas. Using logit and linear probability

models, they estimated the price elasticity of broadband demand at -0.62 (Carare, McGovern, Noriega, & Schwarz, 2015). Since this study focuses on usage subsidy for non-adopters, the price elasticity of broadband demand used in this study is from the Carare et al. study.

While there is no current state-funded broadband usage subsidy program in Minnesota, some low-income households are benefiting from private programs that provide broadband (albeit not meeting the Minnesota speed goals) to low-income households. Comcast, CenturyLink, and Midcontinent are currently offering a $9.95 broadband programs for eligible low-income families, which not only offers discounted broadband services, but also provides Internet training, and an opportunity to buy a low-cost computer.[4, 5, 6] However, none of these low income programs offers broadband service at the statutory speeds (at least 10/5 Mbps): Comcast's *Internet Essentials* program provides 5/1 Mbps service, CenturyLink's *Internet Basics* program provides 1.5 Mbps download service, and Midcontinent's *Broadband Lifeline Assistance* provide 12/1 Mbps service. Comcast's *Internet Essentials* program, for example, has been consistently adding low-income family to its service at an increasing rate (Cohen, 2015), suggesting that price subsidy successfully increased broadband adoption. A state-funded usage subsidy program should be considered in this study as it shall increase subscription rates at the recommended speeds.

3. Subsidy policy options

The Minnesota state legislature set the state broadband goals in 2010 of having universal Internet access for all state residents and businesses with download speeds of 10-20 Mbps and upload speeds of 5-10 Mbps by 2015. These speeds were set to ensure that state residents have broadband service that is fast enough to enable sufficient access to information, communication, business, education, healthcare, and entertainment. Not only has Minnesota planned to become a top broadband state in the US in terms of universal Internet access, it also aims to be in the top 15 in broadband penetration globally (Governor's Task Force on Broadband, 2012). Minnesota currently covers about 78 percent of its households with 10/5 Mbps broadband and is the 19th in comparison on broadband adoption rate globally (Akamai, 2014). Minnesota therefore will not

[4] https://www.internetessentials.com
[5] http://www.centurylink.com/home/internetbasics/?rid=internetbasics
[6] https://www.midcocomm.com/Services/Internet/broadband-lifeline-assistance

meet its goals by the end of 2015, and it needs to improve both the broadband coverage and the adoption rate.

As previously discussed, market failure makes broadband deployment less attractive as a business decision in remote and sparsely populated areas. A fixed-cost subsidy is considered one of the options in this study because it is a common practice of other governments, including the federal government through the American Recovery and Reinvestment Act. This subsidy incentivizes providers to expand their footprints to underserved areas. At the same time, while broadband has lots of benefits, there are people who do not want to subscribe to the service, whether for economic or other reasons. Deploying broadband infrastructure will not cause any benefits without the use of technology. Since non-adopters are most concerned about price, a usage subsidy is included in this study as a mean to increase adoption rate.

3.1 Border-to-Border Infrastructure subsidy

The Border-to-Border Broadband Development Program is chosen as the example of a fixed-cost subsidy due to its current implementation in Minnesota. The Minnesota Broadband Task Force estimates that Minnesota will require total broadband investment of $900 million to $3.2 billion[7] in order to achieve ubiquitous coverage with at least 10 Mbps downloads and 5 Mbps uploads connection (Governor's Task Force on Broadband, 2014b). The Task Force did not suggest that the public will be the only source of funding, but encouraged public-private investment. Nevertheless, this type of subsidy remains an important policy the state legislature is considering to increase funding for the Border-to-Border program. Currently, the program is funded by the state of Minnesota and offers up to 50 percent of the development project's infrastructure costs. It covers 17 broadband development projects across the state (see Figure 2) and aims to connect about 6,100 premises to broadband network in unserved and underserved areas (Office of Broadband Development, 2015).

[7] Costs to deploy broadband infrastructure to every households depend on the population density and the type of technology selected as show in Table 1. For example, connecting every households with fiber-to-the-home will require a higher investment than with DOCSIS3. The caveat in selecting technology is that the chosen technology should have capacity to deliver the speed that the state required.

3.2 Usage subsidy

Due to differences in broadband pricing among service providers and locations, the average price for Minnesota is obtained from Ookla's Net Index[8] which collects real-world speed information and results from user surveys. Net Index's data show that, on average, Minnesotans pay $3.36 per Mbps, which means they have to pay $33.60 to get the service with Minnesota's statutory speed of 10 Mbps.[9] This study will focus on two potential models of usage subsidy. The first model is a broad usage subsidy. This model allows every households in Minnesota to subscribe to broadband service at a reduced price. The subsidy should reach a wide audience, but providing broad-targeted subsidy to people who could afford the service may not benefit low-income households directly. These households would otherwise not be able to afford to have broadband service. Another usage subsidy, designed to target low-income households, will be the second subsidy model included in this study. The low-income usage subsidy will provide heavily subsidized broadband services to low-income households. Both usage subsidy models will use the price elasticity of demand from Carare et al. study of -0.62 to estimate the increased subscribership.

3.2.1 Broad usage subsidy

This subsidy program broadly targets any non-subscribers in Minnesota. Office of Broadband Development reports that 78.16 percent of current 2,087,000 households in Minnesota are served at 10 Mbps/5 Mbps or higher. This means there are about 1,631,000 served households. Of this number, about 38 percent[10], or 620,000 households, are subscribed to connection with that speed. The broad usage subsidy will target every served household with a goal to sign up people who are not already subscribed to 10/5 Mbps broadband. The program is to provide 15 percent reduction in monthly fee, as estimated by Carare et al. in order to increase adoption rate by 10 percent, reducing the monthly fee to about $28.56 ($5.04 subsidy per subscriber).

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[8] http://explorer.netindex.com/maps#

[9] This is not the perfect estimation of broadband price and, in reality, service providers may offer high download speed with low upload speed, which does not meet the state's speed goal. However, according to Ookla's Net Index, the average upload speed in Minnesota is 7.32 Mbps, which is faster than 5 Mbps statutory upload speed. Nevertheless, Ookla's Net Index information is self-selected as users opt-in to run its free speed test (www.speedtest.net) as well as its user survey.

[10] Akamai Research provides national and international information on Internet speed, adoption, and others in its quarter report "State of the Internet." See http://www.stateoftheinternet.com/trends-visualizations-connectivity-global-heat-map-internet-speeds-broadband-adoption.html

3.2.2 Low-income subsidy program

For this study, "low-income households" refer to households with less than $25,000 annual income, just as defined in the Minnesota Residential Survey (Governor's Task Force on Broadband, 2014b).[11] According to the 2013 census, about 19.4 percent of households have an income less than $25,000[12], or about 405,000 households in Minnesota. It is assumed that these households have similar accessibility to 10 Mbps/5 Mbps broadband or higher at 78.16 percent, or about 316,000 households. Since some current low-income households are subscribed to broadband through other private programs for lower speeds[13], it is therefore assumed that none of these households is subscribed to broadband at 10 Mbps/5 Mbps speeds. This subsidy will therefore apply to all 316,000 households. Targeting the subsidy to low-income households could provide service to people who actually could not afford the service otherwise. This subsidy program will offer a more aggressive discount to match the price of existing private programs, like Comcast's *Internet Essentials* or CenturyLink's *Internet Basics*, at $9.95 per month. Low-income households will be able to pay the same amount of monthly fee to connect to faster connections than those offered from existing low-income programs, which will enable them to do more.

4. Study criteria

While both types of subsidy would increase broadband adoption, they operate in different ways and answer different broadband challenges. First, there are some areas in Minnesota that lack broadband services. This means there are households and businesses that do not have access to

[11] The Ultra-High Speed Broadband Task Force suggested the eligibility guidelines as households with total income lower than 135% of the federal poverty guidelines or households that are recipients of other aid programs listed here (Ultra High-Speed Broadband Task Force, 2008):

- Medicaid (Medical Assistance)
- Food support (Food Stamps)
- Supplemental Security Income (SSI)
- Federal Public Housing Assistance
- Low-Income Home Energy Assistance Program (LIHEAP)
- Temporary Assistance to Needy Families (TANF)
- Minnesota Family Investment Program (MFIP)
- National School Lunch Free Lunch Program (NSL)
- Bureau of Indian Affairs Program (Tribal TANF, Head Start Subsidy, NSL)

[12] http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_13_5YR_S2503&prodType=table

[13] Comcast's *Internet Essentials* program provides 5 Mbps download and 1 Mbps upload connection, CenturyLink's *Internet Basics* program provides 1.5 Mbps download connection, and Midcontinent's *Broadband Lifeline Assistance* provides 12 Mbps download and 1 Mbps upload connection.

broadband infrastructure even if they were willing to pay for it. A fixed-cost subsidy reduces the initial capital cost (construction and material cost) and incentivizes service provider to enter these new broadband markets in unserved and underserved areas, which increases the broadband adoption rate. Second, the monthly fee for a broadband subscription is more than some consumers think the service worth. A usage subsidy directly reduces the cost of broadband access which incentivizes price-sensitive consumers to subscribe.

To evaluate the effectiveness of the subsidies, the following criteria that will be used to evaluate both types of subsidy:

1. Number of added subscribers – Number of added broadband subscribers as a result of either type of subsidy.
2. Number of premises passed – Number of households, businesses, and institutions that are affected by the broadband development projects and now have access to the network.

These criteria are used to compare relative cost to each outcome (or cost-effectiveness analysis) to estimate which type of subsidy has more "bang for the buck" for public dollars. Both subsidy options are expected to increase the number of broadband subscribers, but only the fixed-cost subsidy directly increases number of premises passed.

5. Projected outcomes

The outcomes for both types of subsidy are estimated based on available information since neither of the programs is finished (or, in the case of usage subsidy, implemented.) For the fixed-cost subsidy, the state appropriates $19.4 million of public dollar to fund this program. It is assumed that all 17 projects awarded by the Border-to-Border program will meet or exceed their objectives. Therefore, all 6,100 premises will have broadband infrastructure capable of at least 10 Mbps/5 Mbps speed. The subscription rates in these new markets would be the same as the average Minnesota adoption rate, based on the assumption that the services in these new areas will cost similarly to the rest of Minnesota. This means not all 6,100 households will subscribe to the service even with expanded infrastructure. Currently, only 38 percent of households have 10 Mbps or higher connections (see Figure 3) even though the recent Minnesota Residential Survey reports that 77 percent of Minnesota households have "broadband service" (Governor's Task Force on

Broadband, 2014b). It is then assumed that 38% of these 6,100 newly served households will adopt broadband service, resulting in 2,320 households new broadband subscribers.

Table 2 Projected outcome from the fixed-cost subsidy approach

	Subsidy amount ($)	Number of premises passed	$ per passed premise
Fixed-cost subsidy	$19.4 million	6,100	3,180

The results in **Error! Reference source not found.** show that the fixed cost subsidy is expected to achieve its main objective in expanding broadband infrastructure. These 6,100 households in 17 communities across the state will get broadband connection while it would be up to residents' decision to subscribe and use the broadband technology. The estimated number of added subscribers using the latest broadband subscription rate at 38 percent would be 2,320 new subscribers. This observation is similar to Wallsten's projection that broadband infrastructure stimulus is unlikely to contribute much to broadband adoption (Wallsten, 2009). The number estimated in this study is not large, but the subscription rate is not the main objective of a fixed-cost subsidy. Moreover, the direct result from the fixed-cost subsidy, i.e. the expanded infrastructure, will serve those new locations for many years to come. The number of subscriber will therefore continue to change throughout its lifetime. Meanwhile, cost per location passed at $3,180 falls in the range of $2,500 per location passed in urban area and $6,000 per location passed in rural area using fiber optics that the Broadband Task Force estimated in 2012 (Governor's Task Force on Broadband, 2012). This is reasonable considering most of these development projects are in rural or suburban areas and fiber optics is the chosen technology (see Figure 2).

A fixed cost subsidy directly affects the broadband accessibility by increasing number of served households. This consequently expands the service areas that lacked service or were underserved with slower services. A fixed-cost subsidy will be more effective in pursuing the state goal of ubiquitous broadband service, and the expanded infrastructure will allow future customers to subscribe to the service when they see relevancy and value to their lives, such as households with children in school are more likely to subscribe to broadband (Anderson, 2008; Carare et al., 2015; Center for rural policy and development, 2012).

For the usage subsidies, the estimation is based on how consumers react to price. Consumers generally consume more at a lower price. It is safe to assume that once the broadband price is reduced, there will be more adopters. The results are shown in Table 3 In the first scenario, a 15 percent price cut from the current monthly fee of $33.60, around $5, is applied to everyone who signed up for this service. Using broadband price elasticity from Carare et al. of -0.62, it is estimated that about 150,000 households will subscribe as a result of the price cut (See Appendix B). Assuming that all of them sign on this Internet package which costs $33.60 a month and a $5 subsidy is given to all new subscribers, it will cost the state $750,000 per month or $9 million during a year-long program.

For the low-income subsidy program, reducing the monthly fee of $33.60 to match the existing private low-income programs at $9.95 results in a $23.65 price cut per subscriber. Using a similar approach to the broad usage subsidy program, about 138,000 households are estimated to subscribe to broadband (See Appendix B). This will cost the state about $3.26 million per month or $39.2 million for a year-long program.

Table 3 Projected outcomes from the usage subsidy approaches

	Subsidy amount ($)	**Number of added subscribers**	**$ per added subscriber**
Broad usage subsidy	$9 million	150,000	60
Low-income subsidy	$39.2 million	138,000	284

The costs of the usage subsidy approaches are determined by how much is spent on one subscriber and how many subscribers are added. The broad usage subsidy reaches more people and results in more added subscribers, but the added subscribers likely were already able to afford the service even without subsidy. The overall subscription rate may increase, but if Minnesota wants to address the low subscription rate in low-income households, the broad usage subsidy might not target the right population based on the assumption that low-income households can only signup to the service at lower rate. For the low-income subsidy program, the heavily-reduced price also increases broadband subscribers for eligible households. The total subsidy program costs

more than the broad usage subsidy program in this case due to extreme price cut. Nevertheless, it can be concluded that providing a usage subsidy for households to subscribe to broadband for 12 months is effective at increasing broadband adoption rate. Moreover, the effect of a usage subsidy might last even after the program. The Blandin Foundation, a rural development advocate for Minnesota, reports an example of 80 percent of subscribers remain on service after the price increased[14,15]. At this rate, providing a usage subsidy would be a good option to increase a sustaining adoption rate without long-term cost.

6. Limitations of the study and future research questions

This study gives a glimpse into how different public funding policies affect different broadband goals in Minnesota. These policies, however, are either newly implemented (Border-to-Border Broadband Development Program) or hypothetical (both of usage subsidies). Many assumptions were made to address the lack of information in estimating the projected policies outcomes.

Using price elasticity of broadband demand from the study of Carare et al. shows a few limitations. The study uses the most recent survey results from *Connected Nation*'s selected member states. It is assumed that this result is applicable to Minnesota since the study uses the collected results to estimate the price elasticity. Moreover, since the price elasticity is calculated from various demographics, it is assumed that low-income households similarly respond to price as do other groups of people, or that the price elasticity is static throughout the demand curve (i.e. the price elasticity is the same in every price point.) This static price elasticity helps simplify the estimation of added broadband subscribers, because everyone is assumed to react to the change in price the same way. A further study in price elasticity for low-income households is recommended in order to estimate the magnitude of a usage subsidy because they are more sensitive to price than other income groups.

Considering the duration of each subsidy programs will provide more information for policymakers to estimate the cost of the programs. I used one year for both usage subsidy programs

[14] http://blandinonbroadband.org/2012/10/15/reducing-rates-to-get-low-income-folks-online-in-smart-investment-for-providers/
[15] http://blandinonbroadband.org/2014/12/12/surveys-show-that-even-a-small-discount-will-entice-segment-of-non-adopters-to-get-broadband/

because I think the price of broadband service will not change in such short time period. To extend the timeframe, the estimation of future broadband prices need to be made in order to calculate the amount subsidizes by the programs.

The lack of information in this research leads to the use of more generic information and assumptions. The future research in these aspects should provide more accurate analyses on cost-effectiveness of subsidies in broadband development.

7. Conclusions

Despite the limitations in conceiving the study's estimations, there are a few key findings that are valuable to policymakers who work on broadband development programs in Minnesota. Through the cost-effectiveness study, projected results show that different outcomes can be expected from different subsidy models. First, a fixed-cost subsidy program, like the current Border-to-Border program, aim to expand broadband coverage to unserved and underserved areas. It is effective at incentivizing private firms to share the cost of broadband infrastructure construction with the public. The Department of Employment and Economic Development received funding requests for $44.2 million from 40 project applicants (Koch, 2015), clearly showing high interest in the program. A fixed-cost subsidy might not directly promote broadband adoption, but the expanded coverage provides access to people who value broadband and want to subscribe to the service. This result indirectly increase broadband subscription rate throughout the infrastructure's lifetime. It is expected that the technology progress toward Internet-based applications and wider broadband availability will continue to increase broadband adoption rates. Examples can be found even in rural Minnesota where businesses start using social networks to attract customers and establish their brands (IMPACT 20/20, 2013).

A usage subsidy program is very effective at increasing broadband adoption rates. The projected outcomes of this study show that it is less expensive to give a small subsidy that covers everyone than a big subsidy that only covers low-income households. Due to the larger audience, providing a broad usage subsidy to everyone may convince more households to subscribe. However, it would not help narrowing the broadband adoption gap in low-income households as they could only subscribe to broadband at a lower price point. A larger subsidy is required to provide low-income households the opportunity to access broadband, as showed in **Error!**

Reference source not found.. It will come down to what policymakers want to achieve: a higher subscription rate or a narrower broadband adoption gap.

Providing a usage subsidy for low-income households may help them gain access to broadband, but it comes at a high cost. The estimated cost in Table 3 shows that the low-income usage subsidy model costs over four times as much as the broad usage subsidy to support 138,000 low-income households. The cost may be an estimate, but it raises a concern that a large usage subsidy may take funding from other purposes, like broadband infrastructure development. If Minnesota is looking to achieve the ubiquitous broadband coverage, providing a large subsidy might not be a proper way to spend public dollars when more funding is still needed to expand the service to those 22 percent of total households that are currently unserved or underserved.

In conclusion, this study discusses two major types of broadband subsidy: fixed-cost subsidy and usage subsidy. The study uses simple cost-effectiveness analysis to evaluate how these subsidy models affect broadband availability and broadband subscription rate in Minnesota. Since the three subsidy models used in this study have different projected outcomes, the state may need to revisit its broadband goals, especially on broadband adoption. Should the state focuses on just the numbers of subscribers or on the gap in broadband subscription between income groups? The results of this study may provide some aspects on utilizing public funding to achieve the state's broadband goals.

Acknowledgements

I would like to express my gratitude to my academic advisor, Steve Kelley, and Jason Beddow for helping me conceptualize this study. I thank Danna Mackenzie and Diane Wells from the Office of Broadband Development for providing information and other resources. I also thank Professor Robert Kudrle and my peers in my working group class for their supports, comments, and delicious treats.

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Appendix A: Tables and figures references

Table 4 Common Internet Applications by Broadband Speed Range, adapted from (Governor's Task Force on Broadband, 2012)

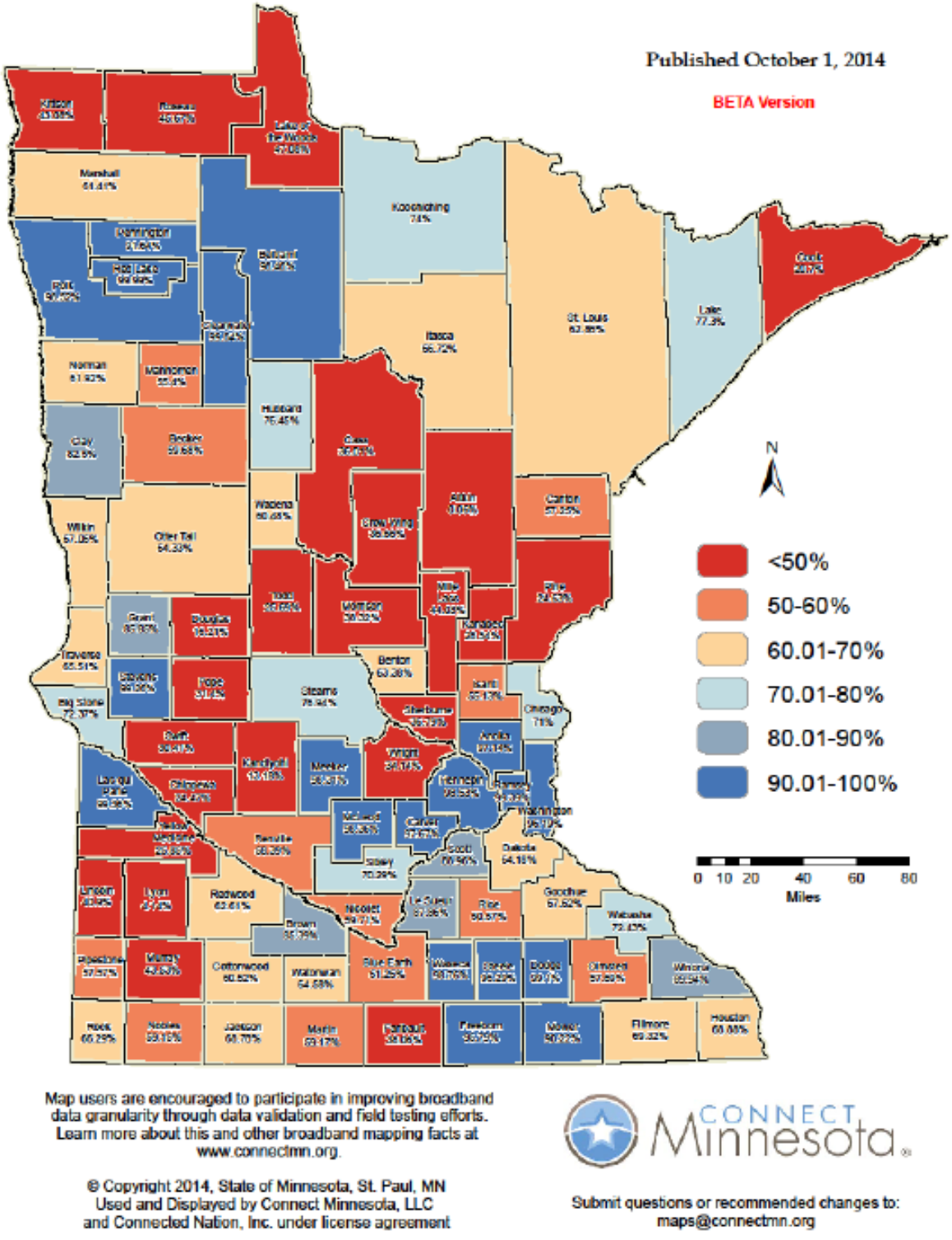
Upload & Download Speed Range	Applications
500 kbps – 1 Mbps	Voice over Internet Protocol (VoIP) Basic Email Web browsing (simple sites) Streaming music (caching) Low Quality Video (highly compressed)
1 – 5 Mbps	Web browsing (complex sites) Email (larger size attachments) Remote Surveillance IPTV-Standard Definition (1-3 channels) File Sharing (small/medium) Telecommuting (ordinary) Digital broadcast video (1 channel) Streaming music
5 – 10 Mbps (Minnesota's lower minimum speed recommendation: 10 Mbps download and 5 Mbps upload)	Telecommuting (converged services) File Sharing (large) Video on Demand (Standard Definition) Standard Definition Video Broadcast Video Streaming (2-3 channels) Low-Definition Telepresence Medical File Sharing (basic) Remote Diagnosis (basic) Remote Education Building Control and Management
10 – 100 Mbps (Minnesota's upper minimum speed recommendation: 20 Mbps download and 10 Mbps upload)	Telemedicine Education Services Standard- and some High-definition video broadcast IPTV-High Definition Telecommuting (high-quality video) HD Remote Surveillance Smart/Intelligent Building Control
100 Mbps – 1 Gbps	High Definition Telemedicine Multiple Educational Services Full High Definition Video Broadcast Full IPTV channel support e-Government (small counties) Remote Server

Table 5 Border-to-Border Broadband Development grant recipients

Grant recipients	Locations	Grant awarded	Total Project Cost	Impact
Arvig (Mainstreet Communications LLC)	Sauk Lake area	$536,702	$1.07 million	217 to unserved premises
CenturyLink Foley	Benton County-Balkan Township	$382,883	$995,977	162 unserved households, 10 businesses, several community facilities
Consolidated Telephone Cooperative	Region 5 Virtual Highway Project	$2 million	$4.22 million	247 unserved and 90 underserved premises
Dunnell Telephone Co.	City of Dunnell in Martin County	$625,000	$1.49 million	174 unserved households
Federated Telephone Cooperative	Big Stone County	$3.92 million	$7.92 million	1,072 unserved premises
Halstad Telephone Co.	Polk County	$1.65 million	$3.3 million	249 unserved locations
Interstate Telecommunications Cooperative (ITC)	Hendriks Town	$700,000	$1.87 million	377 homes and farms, 57 businesses and 8 community institutions (all underserved)
Mediacom	Pintar Road	$137,848	$275,697	122 unserved homes and businesses
Northeast Service Cooperative - Frontier Communications Corp.	St. Louis County	$1.96 million	$4.35 million	877 homes and businesses
Otter Tail Telcom	Swan Lake West	$438,937	$877,874	110 unserved locations
Otter Tail Telcom	Stuart Lake	$105,364	$210,729	47 unserved locations
Otter Tail Telcom	245th	$108,533	$217,105	39 unserved locations
Palmer Wireless	Becker Industrial Park	$151,934	$303,870	21 underserved businesses and 12 vacant city-owned lots covering 70 acres
Rock County Broadband Alliance (RCBA)	Rock County	$5 million	$12.85 million	1,261 homes and farms, 68 businesses, and 21 community institutions
R-S Fiber Cooperative	Sibley and Renville counties	$1 million	$3.32 million	62 unserved and 536 underserved locations
Sjoberg Cable	Roseau County	$261,575	$523,150	107 unserved and 49 underserved homes, farms, and businesses
Wikstrom Telephone	Kittson, Marshall, and Roseau counties	$425,000	$943,827	73 unserved and 43 underserved homes

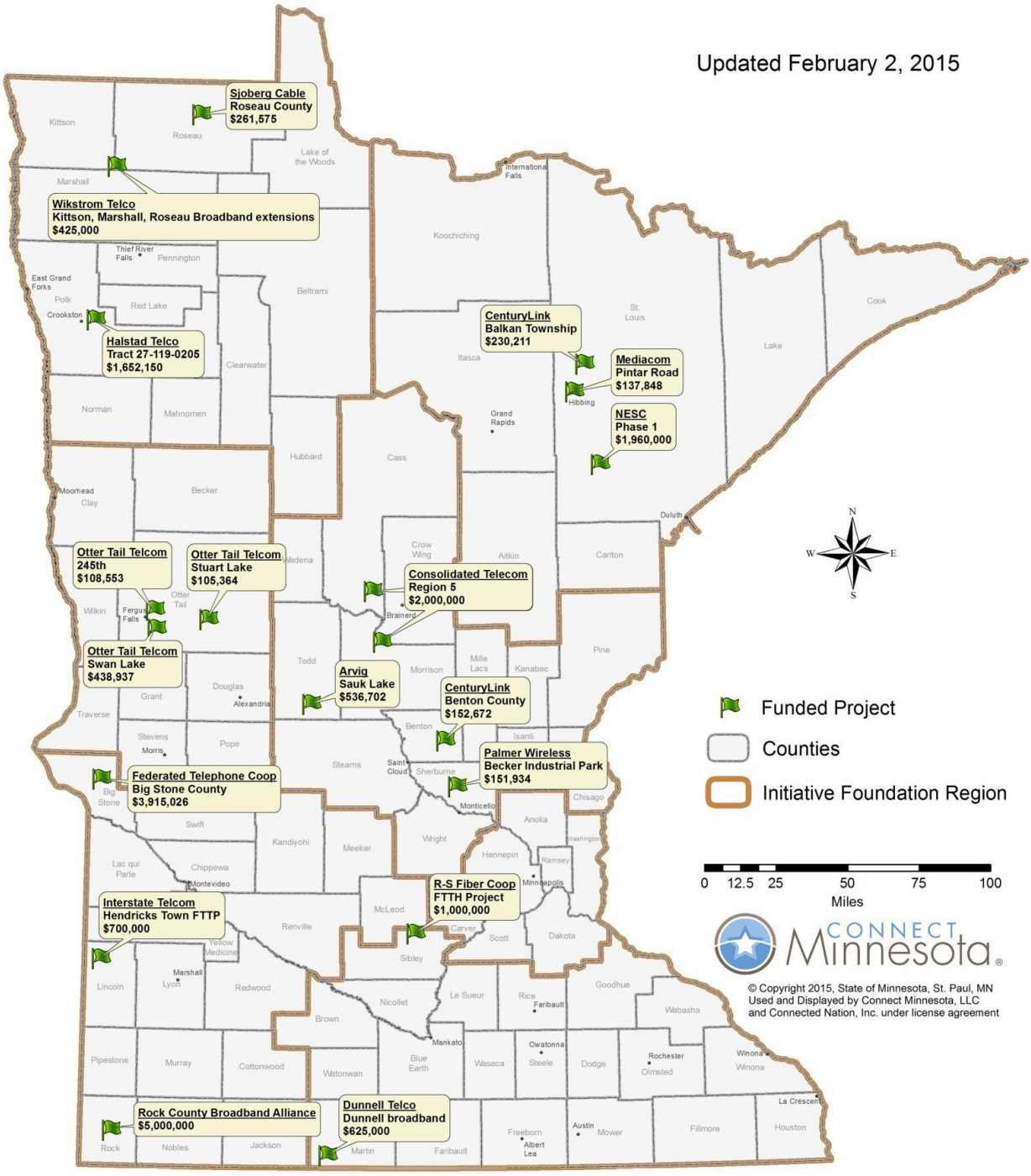
Derived from http://mn.gov/deed/programs-services/broadband/grant-program/index.jsp

Figure 1 Percentage of Minnesota households served by terrestrial, non-mobile broadband with at least 10 Mbps DL/6 Mbps UL speeds



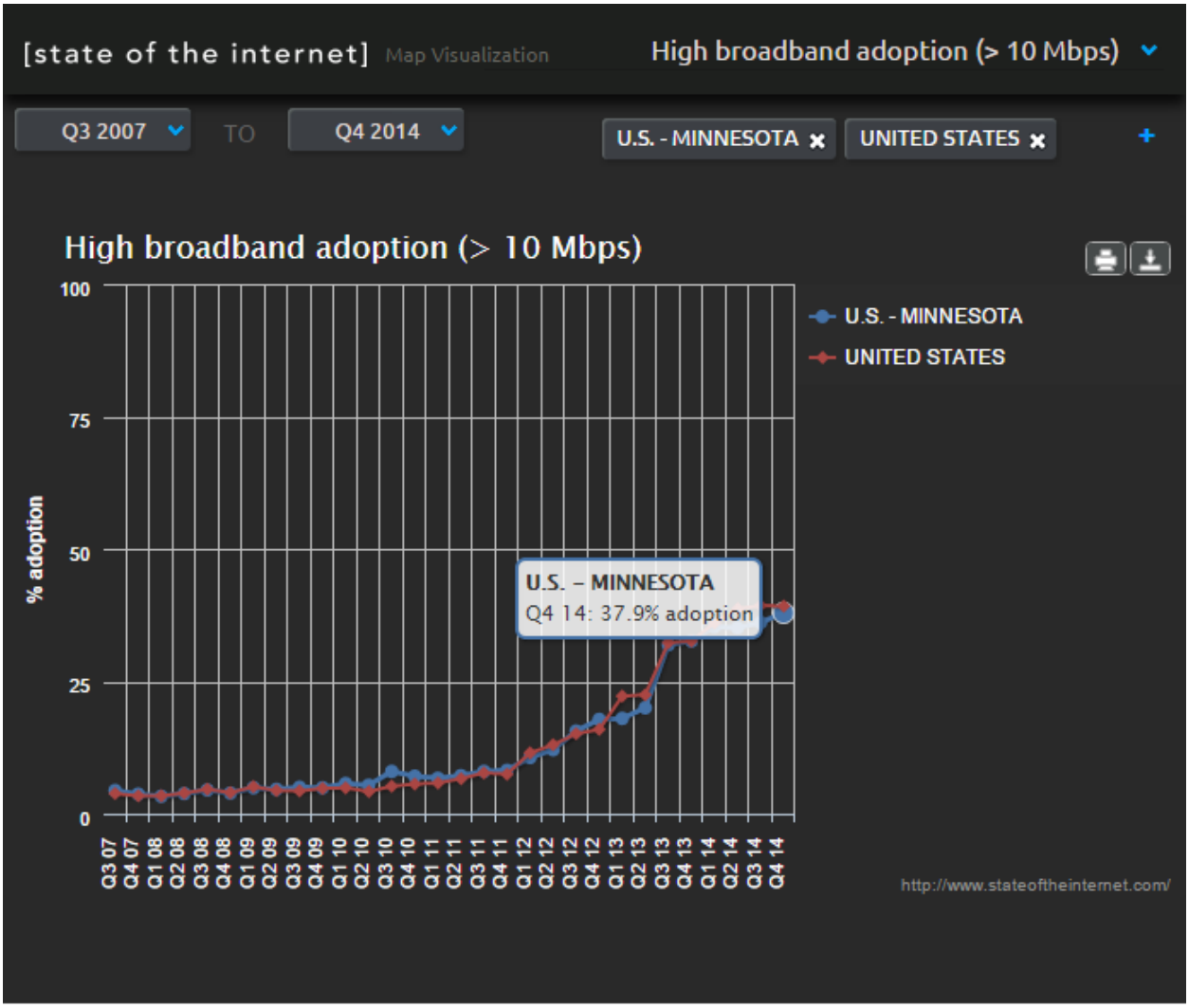
(Governor's Task Force on Broadband, 2014b)

Figure 2 Minnesota Border-to-Border Broadband Development Program



Source: http://mn.gov/deed/programs-services/broadband/grant-program/index.jsp

Figure 3 Broadband adoption rate in Minnesota by Akamai



Source: http://www.akamai.com/stateoftheinternet/soti-visualizations.html#stoi-graph

Appendix B: Estimating the number of added subscribers from usage subsidy programs

The numbers of added subscribers from usage subsidy are estimated using the price elasticity of demand from Carare et al. study. I assume that their price elasticity, -0.62, is applicable and static to people in both subsidy programs. The calculation of the change in broadband subscribers uses the following formula and information.

$$E_d = \frac{\Delta Q}{Q} \times \frac{P}{\Delta P}$$

Where E_d is price elasticity of broadband

ΔQ is the change in broadband subscriber

Q is the number or households with at least 10 Mbps/5 Mbps service

ΔP is the change of price (or amount subsidized per household)

P is the original broadband price ($33.6 per month per household)

The numbers of households served at 10 Mbps/5 Mbps speeds are about 1,631,000 households (for every income brackets) and 316,000 households (for low-income group). The amount of subsidies provide to households are $5.04 per household for the broad usage program and $23.65 per households for the low income program.